Lesson 2
Newton's Universal Law of Gravitation (Review 5.3 in text)

$$F_G = \frac{Gm_1m_2}{r^2}$$

**Note that the gravitational force is always attractive and is dependent on the masses of the objects involved.

Example:
What is the force of gravity between a large sumo wrestler of mass 300.0 kg and a small gymnast of mass 40.0 kg if they are separated by a distance of 1.5 m?

Coulomb's Law
Coulomb's law is very similar in structure to Newton's universal law of gravitation except it involves the force between electrically charged objects.

By charging spheres with different magnitudes and varying the distances between them, Coulomb determined that,

$$F_E \alpha \frac{q_1q_2}{r^2}$$

where F_E = electric force (N)
q_1 and q_2 is the charge on the objects in Coulombs (C)
r = the distance between the charged objects (m)

1 Coulomb of charge = 6.242×10^{18} electrons
(determined by Millikan in the early 1900's)

The charge on one electron is therefore:

$$\frac{1}{6.242 \times 10^{18}} = 1.6 \times 10^{-19} C$$

The charge q on any object must be some whole multiple of the charge on one electron;

$$Q = Ne$$
$$where\ N = \#\ electrons$$

Example:
The electric force between two charged objects is 0.10 N. What will the new electric force be if the charge on one of the objects is made four times larger?

Example:
The electric force between two charged objects is 0.12 N. What will be the new electric force if the charge on one object is made twice as large, while the charge on the other is made three times smaller?

Example:
If the electric force between two charged objects is 0.18 N, what will the new electric force be if the objects are moved three times farther apart?

Note that

$$F_E \alpha \frac{q_1 q_2}{r^2}$$

is a proportionality statement. We add a proportionality constant ‘k’ to get Coulomb’s law:

Coulomb’s Law: $$F_E = \frac{k q_1 q_2}{r^2}$$

$$k = 9.0x10^9 \frac{N \cdot m^2}{C^2}$$

Note that a force of repulsion occurs with like charges and will give a positive value when using Coulomb’s Law, while a force of attraction between unlike charges will give a negative value.

Example:
Calculate the electric force between two charged spheres, each having a charge of 2 μC and whose centers are 10.0 cm apart.

Example:
Determine the electric force between two point charges of 4.0×10^{-8} C and -8.0×10^{-7} C, separated by a distance of 3.0 mm. Is the force one of attraction or repulsion?

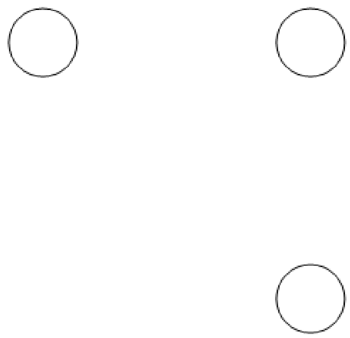
Example:
A small negatively charged sphere is touched by a similar neutral sphere. The two spheres experience a repulsive force of 6.4 N when they are held 10.0 cm apart. What is the magnitude of the original charge on the sphere?

Example:
Find the separation distance between two charges of 2.0×10^{-8} C and -4.0×10^{-7} C, if the electric force between them is -0.80 N.

**Note that Coulomb's law only describes the force between two point charges. For more than two charges we must use vector addition to determine the overall force.

Example:
In the diagram shown, what is the net electric force on sphere B due to the presence of spheres A and C?

Example:
What is the net force on sphere A due to the presence of spheres B and C?



**Note that similar calculations can be done using Newton's universal law of gravitation (see p. 545).

Example:
What is the net force on sphere B due to the presence of spheres A and C?